Lab – 3

Full-field stress analysis using photo-elasticity method

Lab Objectives:

To perform experimental stress measurements on an epoxy beam subjected to four-point bending using photoelasticity. To measure the normal stress variation across the cross-sectional area of a beam, and compare the obtained data to the results predicted by beam theory.

Apparatus Used:

1. Monochromatic light
2. Beam Expander/Collimator and lenses
3. Polarizers
4. Quarter Wave Plates
5. Loading fixtures
6. DSLR Camera/White Sheets to view the fringes
7. Specimen made of Epoxy

Procedure:

1. The dimensions of the specimen needed for beam stress calculations (e.g. length of beam, cross-sectional dimensions, precise locations of supports, precise locations of applied concentrated loads, etc.) is to be measured.
2. The specimen is to be placed and loaded in symmetric four point bend fixture.
3. The source of monochromatic light is to be switched on and aligned in such a way that it falls on the mid-section of the specimen.
4. The specimen is to be tested by applying selected loads, and photo elastic fringe patterns are captured by means of DSLR camera (or by drawing). At each fringe location, the experimental normal stress value is calculated by using the formula

$$\sigma_x = \pm \frac{N f_\sigma}{b} \tag{1}$$

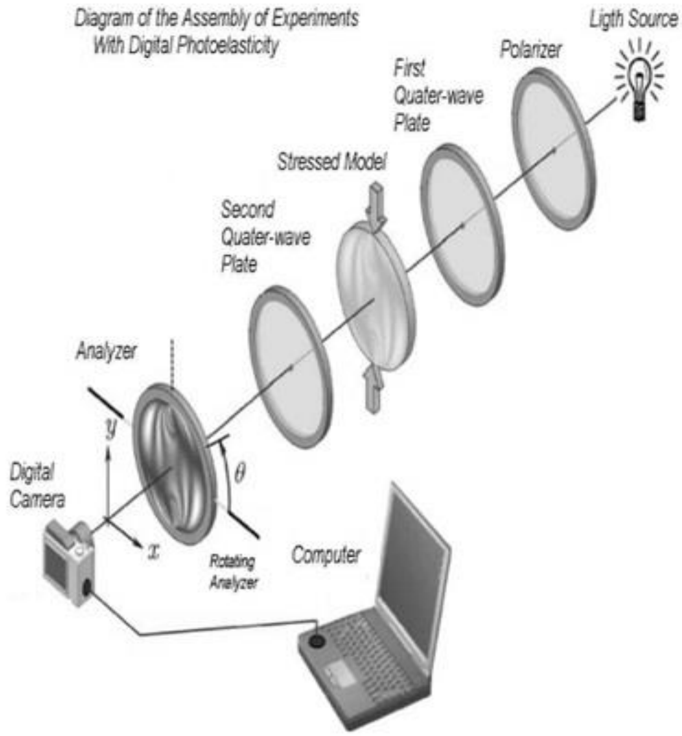
5. The formula

$$\sigma_x(x, y) = \frac{M(x)\, y}{I} \tag{2}$$

is to be used to calculate the theoretical stress distribution over the cross-sectional area of the beam , and compare the results to the photoelastic experimental measurements.

Experimental Setup:

The figure shown below is a schematic representation of the Photo Elasticity Experiment.



As shown in the figure below, each two-force member transfers a force of F/2 to the epoxy beam. This results in a constant bending moment in the center region of the beam (between the inner two forces) with a value of

$$\mathrm{M} = \frac{\mathrm{Fd}}{2}$$

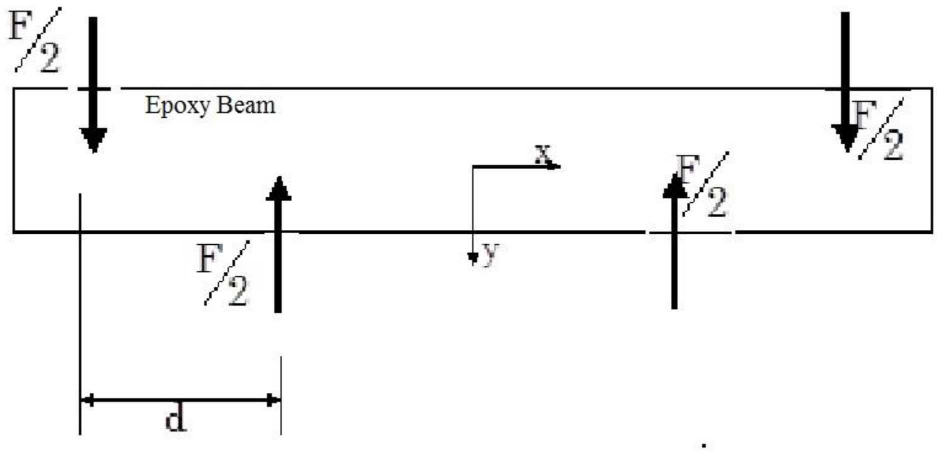


Fig.- Loads on the Epoxy Beam

The theoretical stress distribution on any cross-sectional area in the center region of the beam is given by:

$$\sigma_x(y) = \frac{My}{I} = \left[\frac{Fd}{2I}\right] y = Cy$$

where C is a constant that can be calculated. Using the recorded photo elastic fringe pattern, experimental values of stress σ_x can be calculated at various vertical positions (y). As part of this experiment, a table is to be prepared such as shown below, which lists the measured and predicted stresses at the various photo elastic fringe locations.

Tabulation:

Fringe Location y (inches)	σ_x [Measured]	σ_x [Predicted]	Percent Difference

Results and Discussion:

The plot of σ_x vs. y should be made to graphically compare the theoretical and experimental results. In the graph, use data points for your experimental measurements and a solid line for you theoretical prediction as shown below. The percent errors in the experiment are to be calculated and the possible reasons for the discrepancies are to be discussed.